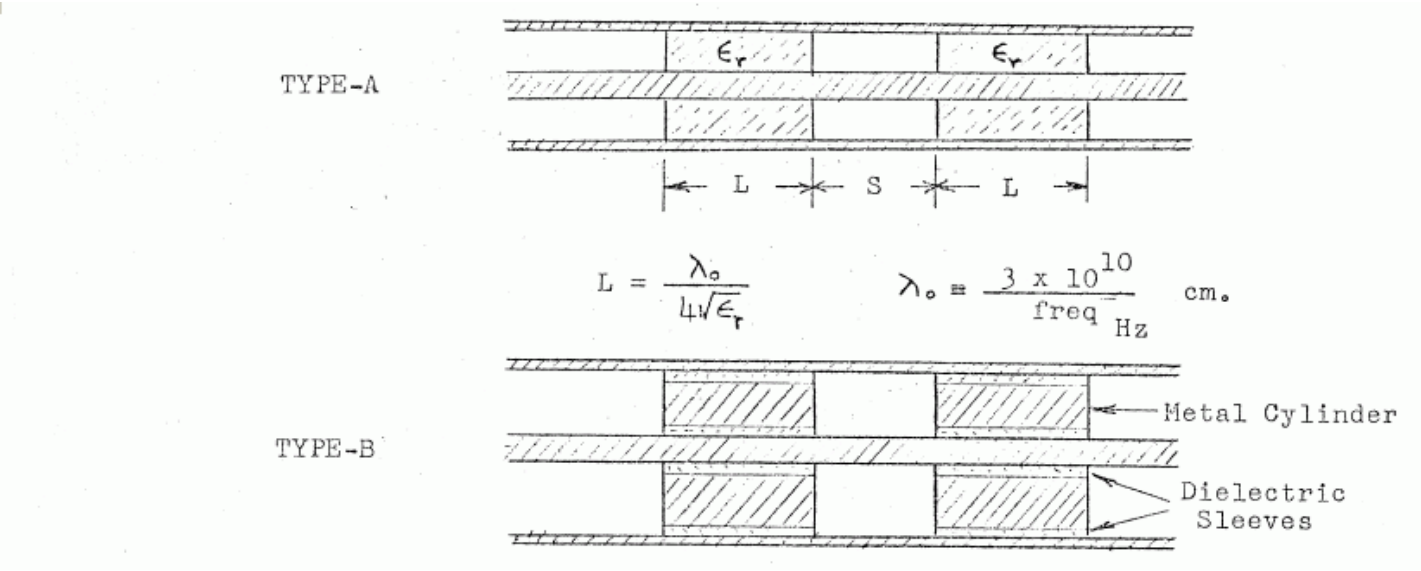
TECHNICAL NOTE #12

From: The Crawford Hill VHF Club, W2NFA

December 1972 SLUG TUNER FOR 1296 MHz

This report describes a low-loss double slug tuner which can be used for impedance matching over a limited range of SWR in coaxial transmission lines at one frequency in the UHF region. This double slug tuner introduces two electrically quarter wavelength line sections into the coaxial line in the form of dielectric slugs or insulated metallic slugs as shown below.



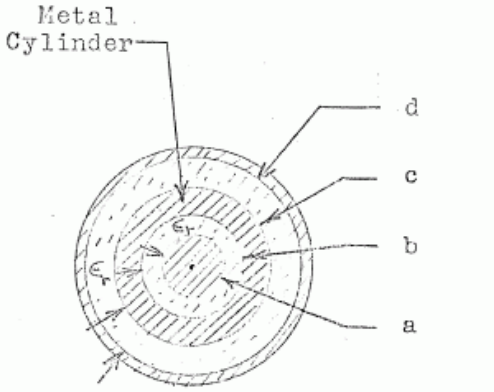
Adjustment of impedance transformation is accomplished by sliding the slugs along the line. This is done through a single narrow longitudinal slot in the outer conductor wall. In a preferred arrangement, the two slugs may be moved simultaneously as a pair. For this case, movement of the pair with constant spacing between slugs affects the Phase of the mismatch while movement of the slugs equally in opposite directions affects the magnitude of the mismatch. In general the slugs may be moved individually in an empirical manner until the desired degree of match is achieved. The maximum value of SWR that may be tuned out is equal to the square of the dielectric constant of the slug.

The property of the double slug tuner which ranks it superior to other type tuners is that there are Do sliding metallic contacts which carry r-f currents. The presence of the dielectric inside the line changes the characteristic impedance of the line in the region of the dielectric by a factor of $1/\sqrt{\epsilon r}$: where ϵr, is the dielectric constant of the material used. For a low loss tuner, the material must have low loss at the frequency of interest. In the UHF region, Teflon. ($\epsilon_r = 2.1$) is the most readily available low loss material which is also easily machined. Some ceramics and other plastics such as polystyrene may be used for low powers but Teflon is recommended at powers exceeding a few watts.

The use of any external impedance matching device interposed in a transmission line or between. circuit and line should be regarded as a "crutch. In some cases however, the tuner may. be a necessary convenience. For example, in matching a high power r-f amplifier to a transmission line, it may be inconvenient to have an adjustable matching device directly in the amplifier circuit. It should be pointed out philosophically that if a large SWR exists on a line, it is not good practice to use a tuner in the line but rather to minimize the SWR initially and then if necessary mop up the residual SWR with a low loss tuner of the type described here.

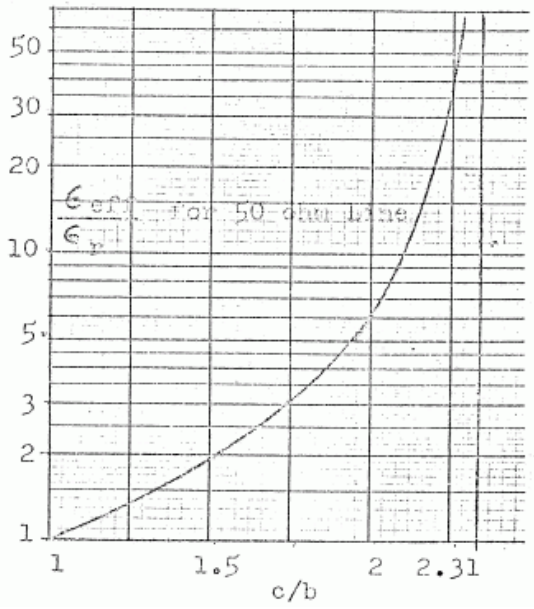
Two designs are shown on the previous page. Type-A uses simple dielectric slugs and is easier to fabricate but has a limited SWR tuning range. Where the SWR may be higher than type-A can handle, type-B is suggested in which the slugs are part metal and part dielectric. In this case, thin Teflon sheet may be used to separate the metal slug from both coaxial conductors. The thickness of the Teflon sheet is determined by the amount of power and magnitude of SWR in the line. For typical cases where powers exceed a few watts, the Teflon should be greater than .010 inches thick.

A cross section drawing of the type-B compound slug is shown below together with formulas to compute the effective' dielectric constant and hence the maximum SWR which can be handled, Note that the length, $L = \lambda o/4\sqrt{Er}$ for the type-B slug is determined by the ϵr, of the insulating dielectric and not the ϵeff of the composite slug.



For 50 ohm air line d/a=2.31
" 75 " " " d/a=3.46

$$\epsilon_{eff} = \epsilon_r \left[\frac{\log_{10} \frac{d}{a}}{\log_{10} \frac{db}{ac}} \right]^2$$



Construction

Construction of a double slug tuner first requires selection of suitable material for the coaxial line commensurate with the desired impedance. For a 50 ohm line, the ratio of the I.D. of the outer conductor to the O.D. of the inner conductor should be as near to 2.31 as possible. Of the commonly available material, inch O.D. copper tubing used in household plumbing has an I.D. of 0.43 inch. For the inner conductor, 3/16 inch (0.1875 inch) diameter rod or tubing results in a ratio of diameters of 0.43/0.1875 or 2.29 which is adequate. The copper tube is of the rigid variety. Although aluminum may be substituted for the outer conductor, the inner conductor should be of copper or at least brass (silver plated if possible) since the surface current density is greatest on the inner conductor.

Figure 1 shows all of the dimensional details of a 50 ohm double Teflon slug tuner for 1296 MHz, Slotting of the tubing can be done in the home workshop on a bench or radial arm saw equipped with a suitable thin metal cutting blade, It is advisable to dowel the inside of the tube first and then clamp the tube securely before sawing. After all burrs are removed from the slot, both ends of the tube should be carefully squared (faced off). Next, the locking nuts of the cable connectors should be bored out to be an easy fit over the inch tube. The nuts may now be soldered on the tube as shown. The use of aluminum for the outer conductor may present a problem with soldering and should be considered when selecting materials.

The center conductor should be cut 1 inch longer than the outer conductor to allow for * inch extensions on either end which are cut down in diameter to fit inside the connector pin. The slight taper at each end should be machined after the pins are properly registered and soldered in place. The taper is not critical and is done to avoid an impedance "bump" and to avoid sharp corner corona. The use of tubing for the center conductor requires that the ends be fitted with short pieces of solid rod to permit soldering of the pins and tapering of the ends as described. Since standard cable connectors do not have captive pins, the panel receptacle (UG58A/U) or equivalent) which does have a captive pin may be preferred as an alternate on one end in some cases.

The Teflon slugs should be machined carefully to be a snug slide fit on the center conductor and an easy clear fit to the outer wall. The slugs are made 1.6 inches long since this is an electrical quarter wavelength at 1296 MHz for a dielectric constant of 2.1. Adjustment of the slugs for tuning is accomplished by means of a thin wooden or plastic blade through the slot. Radiation leakage through the slot should be negligible but do not attempt "hot" adjustment with a metal blade device as coupling will result. Should the very small amount of radiation leakage be objectionable in cases where the tuner is to be included on a permanent or semi-permanent basis, the tube may be wrapped with copper or aluminum foil and taped securely. Weatherproofing may also be accomplished with ordinary plastic electrical tape.

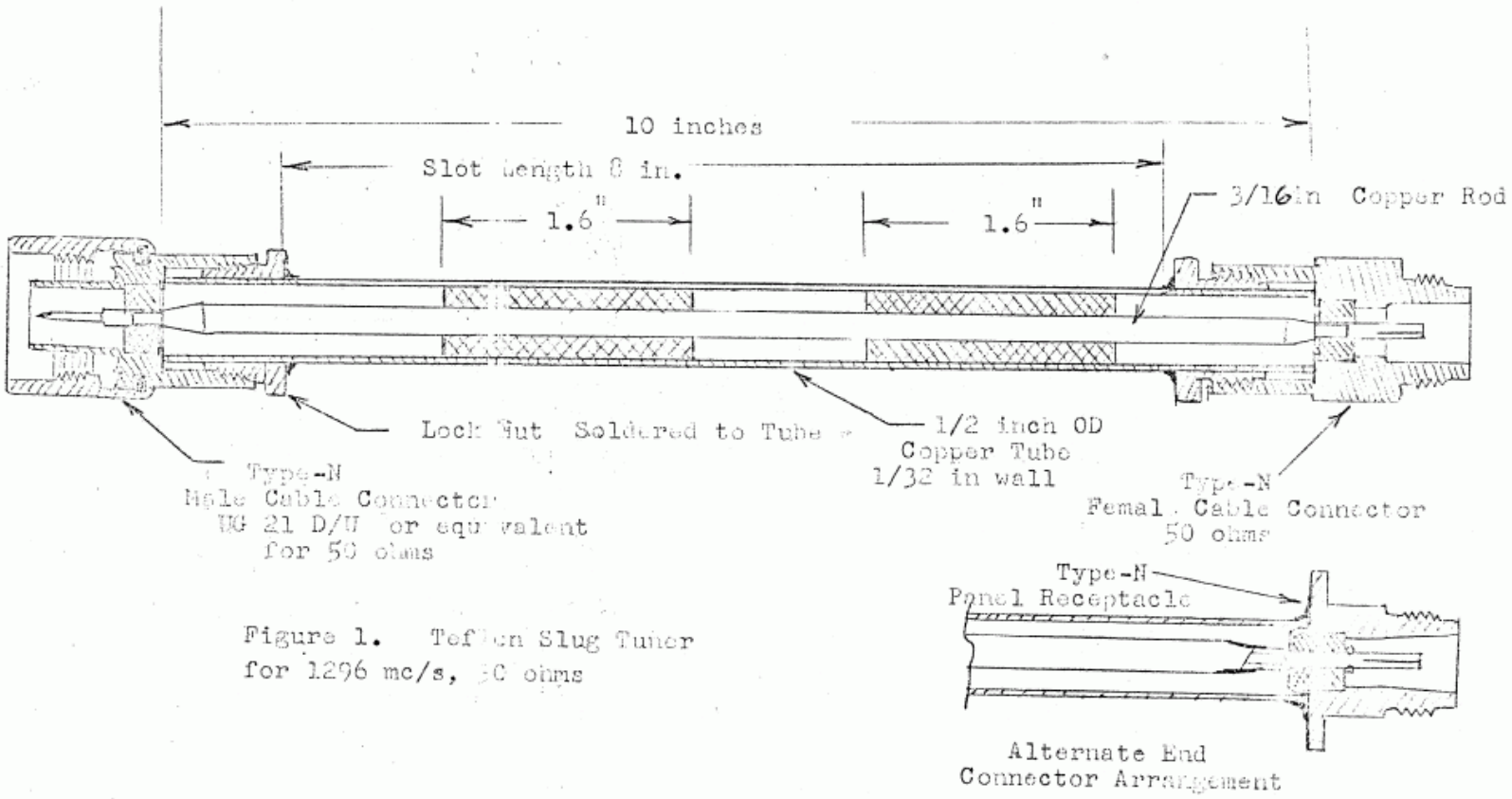


Figure 1. Teflon Slug Tuner
for 1296 mc/s, 50 ohms